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Report of Fishing Industry Science Alliance (FISA) Project 03/13

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Effects of Codend Mesh Size and Twine Number on nephrops Selectivity

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Summary

A set of trials were conducted in the West Coast to examine the selectivity of nephrops (*Nephrops norvegicus*) with regards to codends with the following mesh size and construction:

- 80 mm diamond mesh codend of 4 mm single Brezline (PE) twine
- 100 mm diamond mesh codend of 5 mm double Brezline (PE) twine
- 120 mm diamond mesh codend of 5 mm double Brezline (PE) twine

The results can be summarised as follows:

- For nephrops the catch rates of the 3 test gears differed significantly from each other. At a carapace length of 35 mm the 80 mm mesh showed 77% retention, the 100 mm codend showed 61% retention and the 120 mm codend showed 43% retention.
- For whiting (*Merlangius merlangus*) the catch rates of the 3 test gears differed significantly from each other with increasing selectivity as mesh size increased.
- For haddock (*Melanogrammus aeglefinus*) the selectivity increased as mesh size increased however, that of the 80 mm and 100 mm codends did not differ significantly from each other.

Introduction

The Fishing Industry Science Alliance (FISA) is a joint initiative between industry and science that was initiated in 2012. The alliance draws on the combined expertise of fishermen and scientists to support research that delivers more sustainable and effective fisheries and that furthers scientific knowledge of Scottish fisheries. With the landing obligation for nephrops coming into force on January 2016 when there will a requirement that there will be no discarding of this species by TR2 vessels it is important to understand the selectivity of modern nephrops gears. With this in mind Mallaig and North West Fisherman's Association (MNWFA) put forward a proposal along with Marine Scotland Science (MSS) for a study into the selectivity of nephrops codends constructed from Brezline, a material that is becoming commonly used in the Scottish fleet. Brezline is a polyethylene (PE) braid that is engineered for abrasion resistance, mesh stability and longevity, however, in comparison to standard green PE twine also used in

codend construction it is much stiffer for any given thickness. This has the effect of increasing the mesh's resistance to opening and reducing its selective performance (Sala et al 2007).

In conjunction with MNWFA three industry standard codend sizes were chosen for the study: 80 mm, 100 mm and 120 mm. Both 80 mm and 100 mm are routinely used in the TR2 sector and 120 mm is used in the TR1 sector where nephrops is landed as a by catch. In terms of twine thickness and twine number industry standards were again chosen with the 80 mm codend (102 open meshes round) using single 4 mm Brezline and the two larger sizes (both 88 open meshes round) using double 5 mm. As a first step in understanding how these codends effect selectivity it important to understand the role of each component of their makeup hence this set of trials focussed on the selectivity properties of the mesh size and number only. This is information that is lacking for Scottish codends in general and for Brezline in particular. To this end all other features of a commercial codend that are understood to have an impact on the retention of catch were removed. This means that these trials were undertaken without the use of lifting bags (commonly used in conjunction with the 80 mm and 100 mm codends), chafers (used on 120 mm codends) and square mesh panels (fitted on all trawls).

Materials and Methods

The twin trawl method was used to perform selectivity trails. This is where one net (termed the control) of what is normally a matched pair in a twin-rig setup fishes a small mesh codend which retains the total population of catch of all species. The other net (the test) differs from the control only in the feature(s) under examination. Here the features under examination are mesh size and number. Catches from the test are compared to catches from the control and expressed as a proportion retained of the total population. MFV Ocean Trust PD 787 was chartered for the purpose and the trials were undertaken during 11-23 July 2014 on commercial west coast nephrops grounds. The target species for all hauls was nephrops. Certain species of commercial whitefish were worked up as available but these were not targeted to the exclusion of nephrops.

The twin-rig fished by the Ocean Trust utilised a matched pair of Pisces Prawn Trawls. These had a fishing circle of 440 x 85 mm (nominal size) meshes and were constructed from 4 mm PE twine. The groundgear consisted of 19 m (62') of central 350 mm (14'') hoppers, 9.1 m (30') of 350 mm (14'') discs and 4.6 m (15') each side of straight rubber leg to a total length of 19 m (62'). Sweeps consisted of 12.7 m (42') of splits (16 mm rubber covered wire on bottom and 16 mm bare wire on top) followed by 18.1 m (60') of single (16 mm rubber covered wire) going out to the doors. The trawls were fished using a three-warp system utilising a 500 kg roller clump and 180 kg 1.63 m (64") Perfect Patent B doors. This is a commonly used configuration amongst TR2 vessels in the North and South Minch.

For the test codends a range of Brezline netting was measured at various suppliers using a standard Omega gauge and a mesh size chosen that reflected as far as possible that of a commercial net that had been actually fishing for some time. Many codends are bought 5-8 mm oversize on the understanding that with usage the meshes shrink towards the regulation size. Thus for these trials the sizes chosen were 3-4 mm over the nominal size which equated to between 3.3-4.0% larger for each (Table 5). To obtain definitive measurements for this report the mesh size was again measured wet, both pre-trials and immediately after completion (Table 6). The control net used a codend and extension constructed from 40 mm mesh. A diamond mesh of this dimension is considered to retain all individuals of target species going into the mouth of the net.

Trials were conducted in the North and South Minch on commercial Nephrops grounds with the exact areas being selected after daily consultation with the skipper of the Ocean Trust. Most hauls lasted between 2 and 3 hours, with the vessel generally towing at its normal fishing speed of 2.6 – 2.8 kts. To minimise tidal effects on the twin rig geometry hauls were conducted, as far as possible, either with or against the tide. To counter possible net bias the relative positions the test and control codends were swapped around at appropriate interval ensuring the test net was trailed on both port and starboard sides. Wingspread outputs from Scanmar sensors attached to the wingtips were recorded. Headline height however, was not recorded as this design of net has a lower headline than the accepted threshold for reliable information from scanmar height units (~3 m).

On completion of each haul both codends were lifted free of the water and processed separately. All nephrops were removed from the catch and to counter any potential sorting bias they were then all placed into a large tub where they were mixed thoroughly in seawater to homogenise the size classes. Nephrops were then removed into baskets and allowed to shed excess water. A total weight was recorded prior to subsampling using calibrated Nesco sea-going scales or a calibrated 50 kg Salter hanging balance.

Subsampling was by weight and the sample varied between approximately 16-28 kg depending on the size makeup of the samples; this corresponded to around 700-800 individual nephrops measurements per codend per haul. The measurement recorded for all nephrops was carapace length (cl) to the mm below. This is the minimum length from the inside of the eye socket to the posterior margin of the carapace which is standardly used to provide a non-ambiguous measurement for lobster-like crustaceans. All hauls had a moderate component of fish and haddock, whiting, cod (*Gadus morhua*), saithe (*Pollachius virens*), hake (*Merluccius merluccius*), plaice (*Pleuronectes platessa*), lemon sole (*Microstomus kitt*), witch (*Glyptocephalus cynoglossus*), megrim (*Lepidorhombus whiffiagonis*) and monkfish (*Lophius piscatorius*; *L. budegassa*) were additionally sorted from the catch and measured. Where juvenile haddock and whiting were in great abundance the catch was subsampled by volume for

these only with all individuals of other important species being fully sorted out. The non-commercial species and invertebrates forming the remainder of the catch were recorded as a bulk weight. Fish were measured to the cm below and after obtaining a full length frequency an estimated total weight was obtained using an in-house weight to length program. Catches (weight) per side are summarised in table 1.

Data Analysis

For each species where there were sufficient data, the catches from the test and control codends were analysed using the smoother based methodology of Fryer et al. (2003). The analysis is in three stages: a smoother was used to model the log catch rate of the test gear relative to the control gear for each haul; the fitted smoothers were combined over hauls to estimate the mean log relative catch rate for each gear; and bootstrap hypothesis tests using the statistic Tmax were used to assess whether the mean log relative catch rates depended on the gear fished, and to compare the mean log relative catch rates to zero (or equivalently the mean relative catch rates to unity).

All p-values of pairwise comparisons have been adjusted for the number of comparisons, unless otherwise stated. The analysis was on the logistic scale, but the results have been back-transformed for presentation.

Results

A total of 43 hauls were undertaken of which 41 were considered valid. The valid hauls consisted of 13 with the 80 mm codend, and 14 each with 110 and 120 mm codends. Conditions were calm and settled throughout the trials. In common with the West Coast fleet in general during this period the trials encountered unseasonably poor nephrops catches. Various commercial tows on a variety of grounds in the North and South Minch (Figure 14) were thus worked in an effort to produce the desired numbers for analysis. All hauls were, however, successful in catching some nephrops and overall 59400 individuals were measured during the course of the trials. In the North Minch a large proportion of the nephrops catch was of a very small average size however, some moderate hauls of large individuals were obtained in the South Minch. Many hauls exhibited a sizeable component of 0-group (<1 year old) haddock and whiting in the control net along with moderate amounts of bigger individuals of both species. In the test net 0-group fish were generally few in number (Figs 1, 3). There were small amounts of several other commercial species additionally present in most hauls.

All test cases exhibited a reduction of the overall bulk as compared to the control (Table 1). This reduction varied widely (25-82%) depending upon the makeup of by-catch; catches with a relatively high component of juvenile gadoids, Norway pout (*Trisopterus esmarkii*), and red shrimp (*Pandalus sp*.) demonstrated the largest reductions as compared to hauls where moderate–sized saithe, herring (*Clupea harengus*) and lesser spotted dogfish (*Scyliorhinus canicula*) were prominent.

Wingspread data was obtained for most hauls with both port and starboard nets exhibiting similar spreads throughout the trials. There were 6 hauls where there was no data obtained and a further 8 where data was obtained for one side only. Averaged over all hauls the port net had a mean wingspread of 8.4 m while the starboard net had a mean of 8.5 m (Table 3).

Overall there were enough nephrops, haddock and whiting to produce reliable selectivity information for all three test codends. Additionally there were enough plaice and witch to provide selectivity information for the 100 mm codend. For lemon sole and hake there were too few fish caught for smoother analysis, however, there are initial indications of potential selectivity occurring for certain of the test cases. For other species numbers were too few for any analysis at all (megrim) or most of the individual fish were too large for any selectivity to take place with these gears (cod, saithe, monkfish). For each species the results are summarised as follows:

Nephrops

The catch rates of the 3 test gears differed significantly from that of the control net and from each other. For the 80 mm codend retention was 39% for individuals of 20 mm cl rising to 87% at 38 mm with no significant difference from the control net at sizes greater than this. For the 100 mm codend retention at 20 mm cl is 31% rising to 68% at 38 mm, and not significantly different from the control net at sizes greater than 47 mm. For the 120 mm codend retention is 33% at 20 mm cl rising to 46% at 38 mm and 71% at 54 mm which represents the largest size class that could be analysed (Figure 1).

Haddock

The catch rates of the 3 test gears differed significantly from that of the control net. Both the 80 mm and 100 mm codends were significantly different from the 120 mm codend, however, the 80 mm was not found to be significantly different from the 100 mm (Table 4). For the 80 mm codend retention is <1% for fish under 10 cm rising to 56% at 19 cm above which no significant difference from the control net can be demonstrated. For the 100 mm codend retention is <1% for fish under 11 cm rising to 45% at 19 cm. For haddock greater than 23 there is no significant difference from the control net. For the 120 mm codend retention is <1% for fish under 12 cm

rising to 18% at 19 cm (Figure 2). For haddock greater than 30 cm there is no significant difference from the control net (not illustrated on figure).

Whiting

The catch rates of the 3 test gears differed significantly from that of the control net and from each other. For the 80 mm codend retention is <1% for fish under 10 cm rising to 58% at 23 cm above which there is no significant difference from the control ne. For the 100 mm codend retention is <1% or for whiting under 13 cm rising to 21% at 23 cm with no significant difference from the control being demonstrated for whiting larger than 27 cm. For 120 mm codend retention is <1% for whiting under 19 cm rising to 8% for fish at 23 cm with no significant difference from the control net for individuals larger than 32 cm (Figure 3).

Plaice

For plaice there were enough data to produce smoothed results for the 100 mm codend (Fig.8) which was significantly different than the control. The relative catch rate is 5% for fish at 20 cm rising to 49% for fish of 24 cm and not significantly different from the control for plaice larger than this. The control retained fish down to 18 cm and the test down to 19 cm. Production of smoothed results was not possible for the other two codends however, the 80 mm sowed very similar catches for both test and control over a size range of 18-32 cm. For 120 mm there were too few fish caught for smoother analysis however, the test retained very few of the size range of 17-29 cm as caught by the control (Fig. 7).

Witch

For witch there were enough data to produce smoothed results for the 100 mm codend (Fig.10) which was significantly different to the control. The relative catch rate is under 12% for witch at 20 cm rising to 47% for fish of 26 cm and not significantly different from the control net for lengths greater than this. The control retained fish down to 9 cm and the test down to 10 cm. Production of smoothed results was not possible for the other two codends however, the 80 mm codend showed potential selectivity occurring over the 10-20 cm size range with fish of 10 cm being retained by the control net and no fish under 19 cm being retained by the test. The 120 mm codend showed potential selectivity up to approximately 35 cm however, there were very few fish retained by the test and interpretation remains unclear. The control retained fish down to 16 cm and the test down to 15 cm (Fig. 9).

Lemon sole

Relatively low numbers of lemon sole in the approximate size range of 13-32 cm were caught by the control net for all mesh comparisons. The test nets all retained fish of 18-19 cm and larger however, there were too few overall for smoother analysis. Only the 100 mm codend retained enough to indicate some potential evidence of selectivity occurring for fish under 22 cm (Fig. 11).

Hake

Relatively low numbers hake in the approximate size range of 15-68 cm were caught by the control net for all mesh comparisons. The smallest fish retained by the 80, 100 and 120 cm meshes were 16 cm, 20 cm and 19 cm respectively. There were too few fish caught to analyse however, there is slender evidence of selectivity occurring over ~15-20 cm size range in the case of 80 mm and 15-25 cm in the case of 100 mm. The 120 mm codend also caught hake over these same size ranges however, there were few of them (Fig. 12).

Cod

The trial encountered low numbers of cod over a size range of 7-59 cm, many of which were too large to produce selectivity data for the mesh sizes trialled in any case. However, none of the test codends retained any cod over the size range 7-11 cm while overall 12 fish of this size were retained by the control codends (results not illustrated).

Monkfish

All test and control nets retained monkfish over a size range of approximately 10-55 cm. Both NE Atlantic species were present and for the purposes of this report the numbers of each were combined. However, overall numbers were too low to say whether there was any selectivity occurring, and again many fish were of a size that precluded any possibility of selection taking place. The smallest size of monkfish (10-11 cm) retained in the test codends were in all cases close to or the same as the smallest size (9-11 cm) caught by the control net (results not illustrated).

Saithe

The 100 mm and 120 mm trials encountered moderate amounts of saithe of size range 25-45 cm. The number of hauls containing saithe data were too low to provide reliable analysis and again as expected for fish of this size there is no pattern of selectivity evident. The 80 mm trials

encountered very low numbers of saithe of the same size range, again with no selectivity evident (results not illustrated).

Megrim

Numbers of megrim (15-46 cm size range) caught during the trials were very low and no analysis is possible (results not illustrated).

Discussion

The results of these trials clearly demonstrate the increasing selective performance of the 80 mm, 100 mm and 120 mm Brezline codends for nephrops, haddock and whiting. The catch rates of nephrops for all three test cases differed significantly from those of the control net and from each other. Table 2 shows relatively large reductions for nephrops in terms of weight. This is in line with the overall very small mean size of nephrops encountered during the trials which peaked between 32-34 mm cl depending on the test case (Figure 1). This peak corresponds roughly to a large discard or standard tailed size class in the Minch fishery according to 2013 MSS observer data (Figure 13).

For the 80 mm mesh most selectivity occurs over the lower size range up to approximately 38 mm cl a size range that contains discards, tailed and the smallest class of nephrops that are landed as whole. With the 100 mm some selectivity also occurs over 39-47 mm size range which encompasses the medium whole class. For 120 mm there is some selectivity across the full length range analysed. The largest increases in selectivity between the three test cases are observed over the 25-40 mm size range. As expected there is a marked increase in retention with increasing carapace length in all cases until there is a point where all individuals at a given size are retained. For the 120 mm mesh the analysis ran to a maximum size of 54 mm at which point retention was approximately 71%. This size is considered as category ‘large’ in the Minch fishery. Nephrops of much greater size than this are not generally encountered in any numbers. Figure 13 illustrates that, as expected with diamond mesh codends, not only is there no sharp dividing length at which a given mesh size will retain all individuals there is also a great deal of overlap between landed and discarded classes in the commercial fishery. In approximate terms a nephrops of 25 mm cl has an approximately 50:50 chance of being discarded or landed. If landed this will almost certainly be as part of a ‘small tailed’ class but with a minor chance of being part of a ‘small whole’ category. The 80 mm mesh in the configuration trialled will reduce those discards by a further 50% but it will also reduce these classes of marketable *Nephrops* by a similar amount.

The minimum landing size (MLS) of nephrops for Area VIa is 20 mm cl and when comparing this to the population caught by the control net (Figure 1) there is little evidence of a problem

with undersize nephrops where the trials took place. It is noticeable that for nephrops close the MLS there were observed only relatively small differences in catch rate (31-39%) between the three test gears. In particular there was little perceptible difference observed between the 100 mm and 120 mm mesh for nephrops up to 25 mm cl after which the trends diverge.

The pattern generally continues with haddock and whiting with the exception that there was no significant difference between the 80 mm and 100 mm codends for haddock. Table 2 illustrates the percentage retention by weight for the three main species encountered. For haddock and whiting the retention is low ranging from 12% to 30% according to species and mesh size however, the percentages do not all track from highest to lowest along with increasing mesh size as may be expected. This is due in part to the varying length frequencies encountered by each test case. The majority encountered were this year's juveniles of very small size (~7-14 cm) and all three codends exhibited broadly similar selective properties with regards this size range (Fig. 4). The catch component of the larger size classes was more variable between hauls, particularly in the case of whiting. This variation has influenced the overall percentage reduction to give a non-linear pattern with increasing mesh size that would not be seen had the relative proportions of large and small gadoids been constant between the test cases. However, the catch rates over the two main size groups are well illustrated in figures 3 and 5. It is worthwhile noting that the retention of small gadoids is low for all of these codends even in the absence of a square mesh panel which would be normally installed on all commercial trawls.

It must also be recognised, however, that these trials were undertaken without ancillary devices such as SMPs and, importantly, without the lifting bags or chafers that are in common use commercially and this must be borne in mind when considering results. The reason lifting bags, chafers or SMPs were not used during these trials was to focus solely on the effect of codend mesh size. If they had been used more uncertainty would have been introduced and the results would have been more difficult to interpret. Lifting bags (applicable to the 80 mm and 100 mm codends) are attached top and bottom and encircle the codend while chafers (applicable to the 120 mm codend) do not encircle the codend and are attached top only. Furthermore, the mesh size of lifting bags and chafers would be at least twice the size of that of the codend mesh and hence would introduce even more variability. A meta-analysis of nephrops trawl selectivity has shown that lifting bags reduce selectivity (ICES WKNEPHSEL 2007) and directed trials in whitefish gears have shown similar results for haddock (Kynoch et al, 2004)).

This study is not seen as a standalone set of trials but rather the first of a series leading to an understanding of current commercial nephrops codends in terms of their selectivity. Ultimately these will demonstrate the implications of moving from one mesh size to another in terms of the demands of the landing obligation. At the time of writing a FISA proposal to examine the

selectivity of lifting bags on a nephrops trawl has been accepted for funding and the study will commence in 2015.

Acknowledgements

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Appendix: Tables and Figures

Note: for the relative catch rate figures below a solid line denotes where the catch rate is significantly different from 100 %. A broken line shows where the rate is not significantly different.

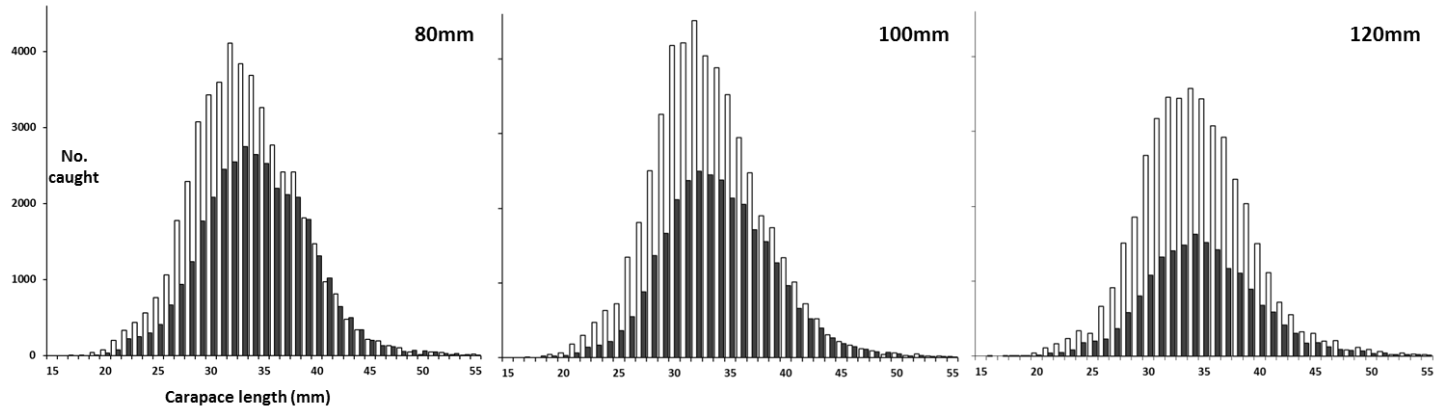

Figure 1. Comparison of raised nephrops length frequency for the control net (white bars) and the three test nets (black bars). Results are amalgamations of all hauls for the particular test case.

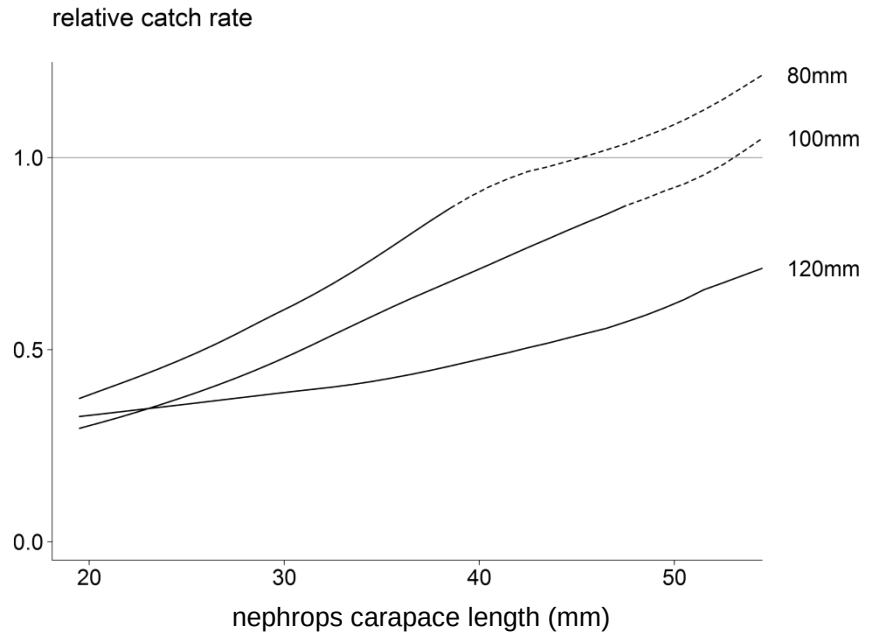

Figure 2. The relative catch rate of nephrops by codend from smoothed data.

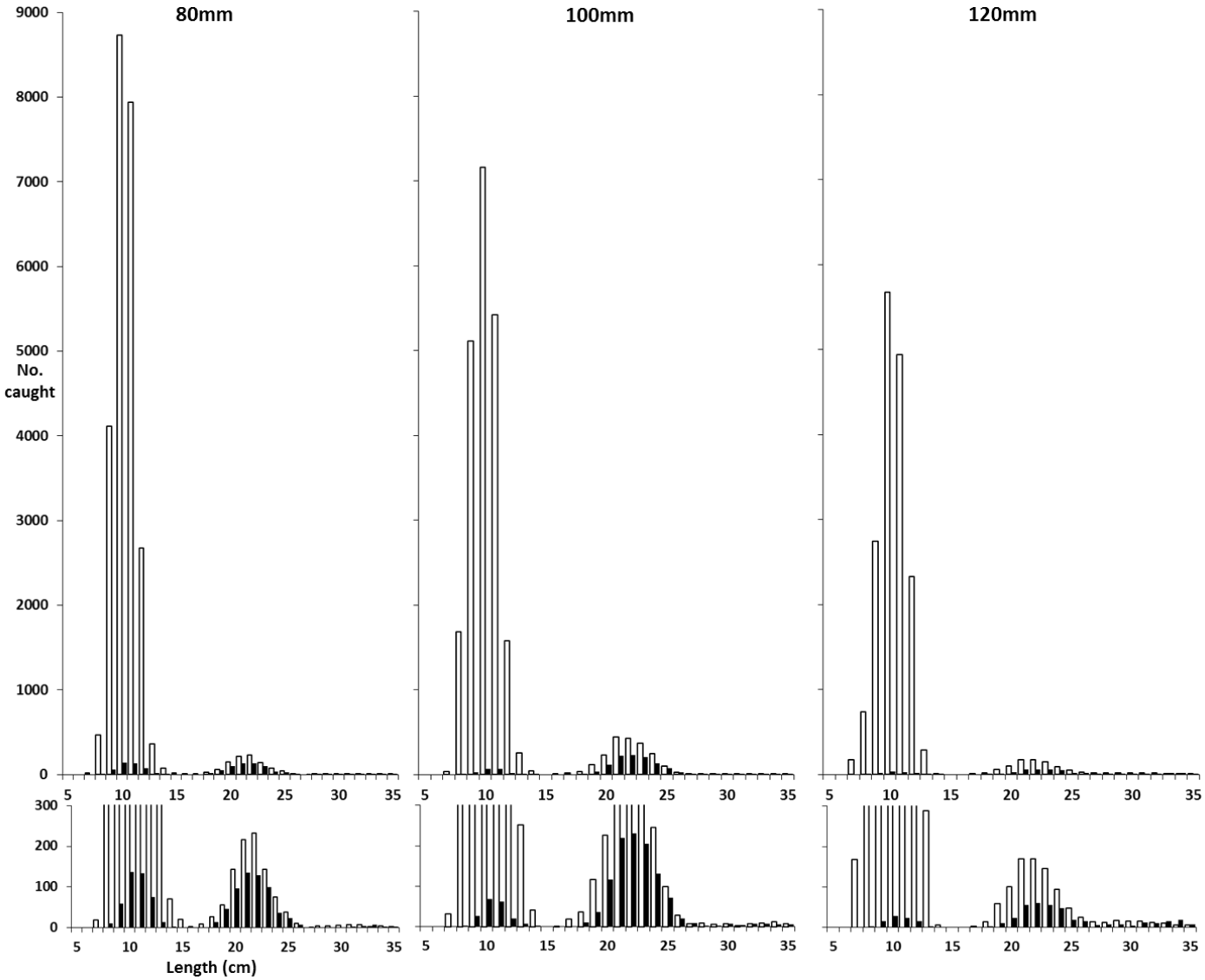

Figure 3. Haddock - top row: combined number caught v length by the control (white bars) and test nets (black bars). Bottom row: focus on the numbers from the test net.

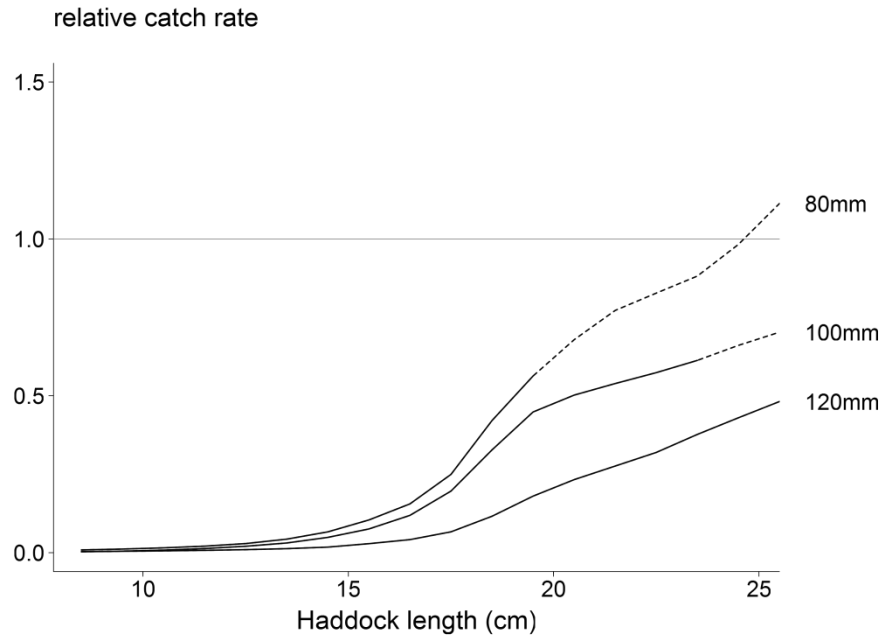

Figure 4. The relative catch rate of haddock by codend from smoothed data. Note that in the case of the 120 mm codend the analysis shows that the trend with length continues and that for haddock >30 cm the relative catch rate is not significantly different from the control net, however, this is not illustrated here.

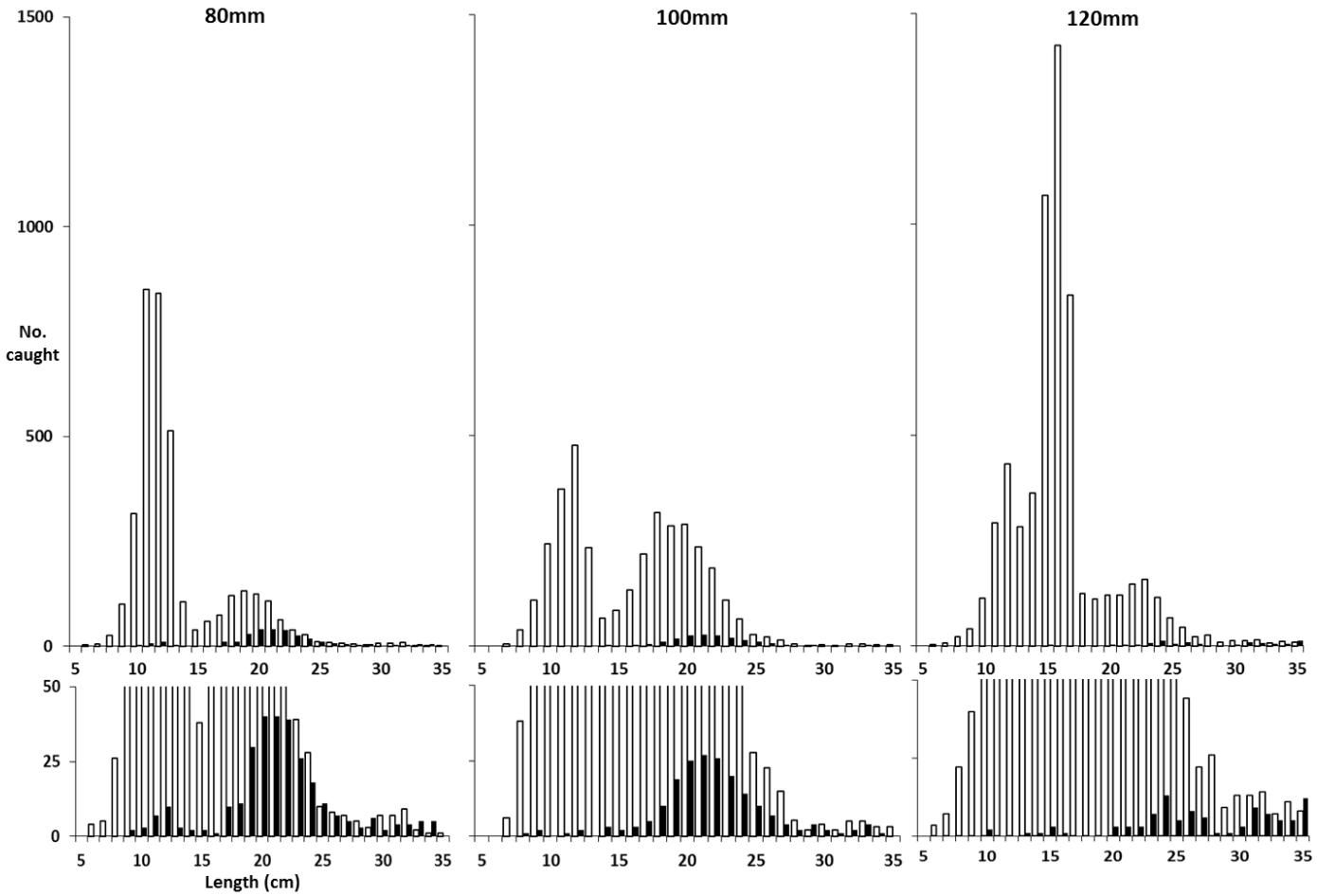

Figure 5. Whiting – top row: combined number caught v length by the control (white bars) and test nets (black bars). Bottom row: focus on the numbers from the test net.

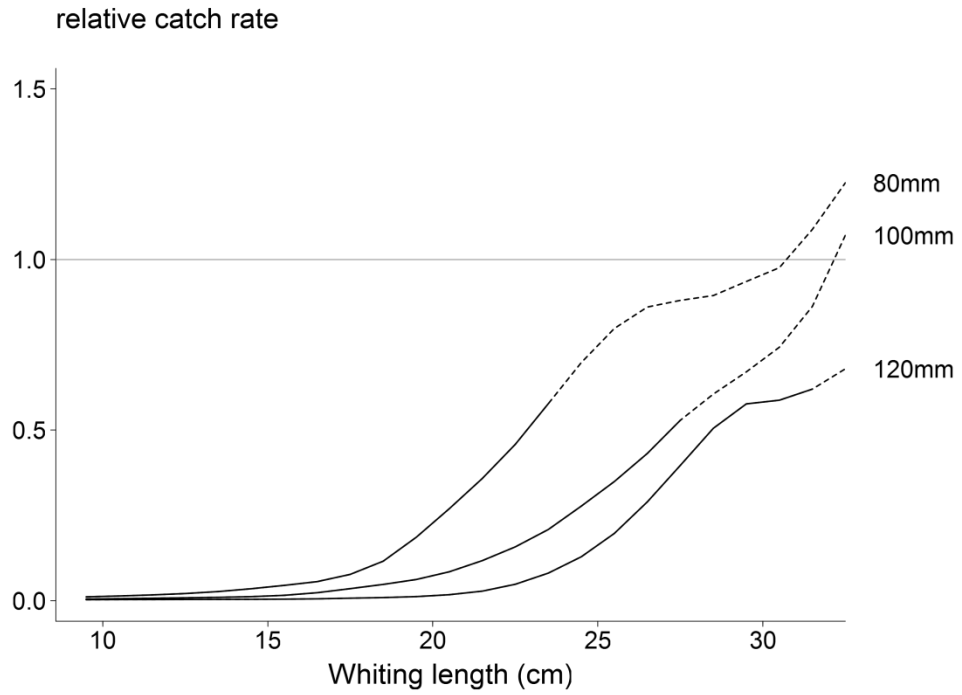

Figure 6. The relative catch rate of whiting by codend from smoothed data

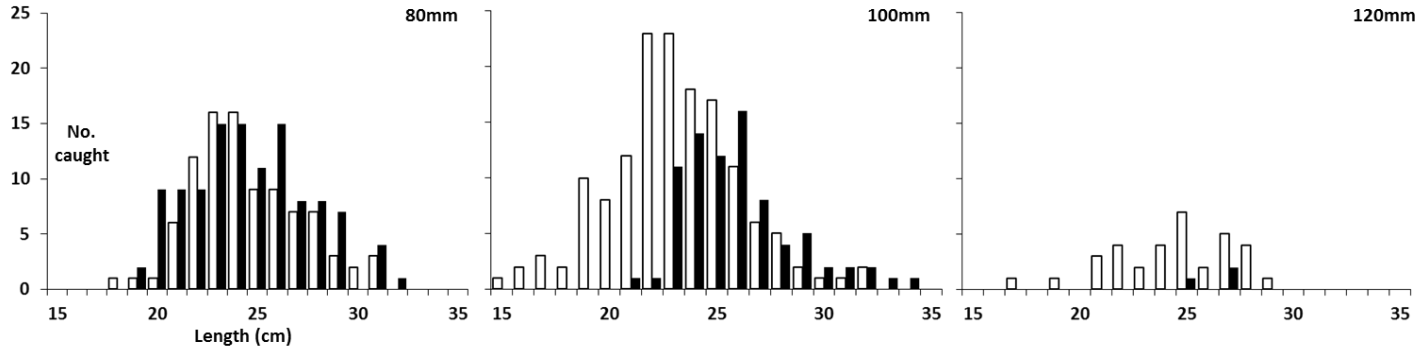

Figure 7. Plaice combined numbers caught at length by the control nets (white bars) in comparison to the test nets (black bars).

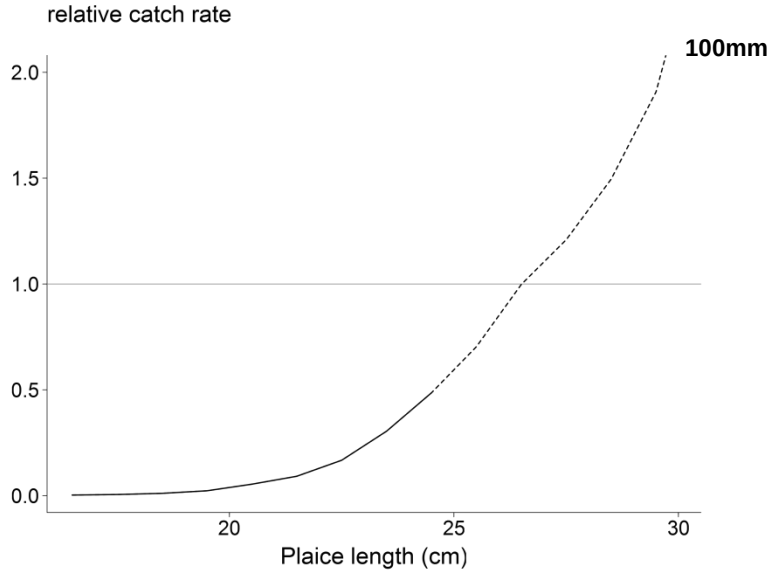

Figure 8. The relative catch rate of plaice for 100 mm codend from smoothed data.

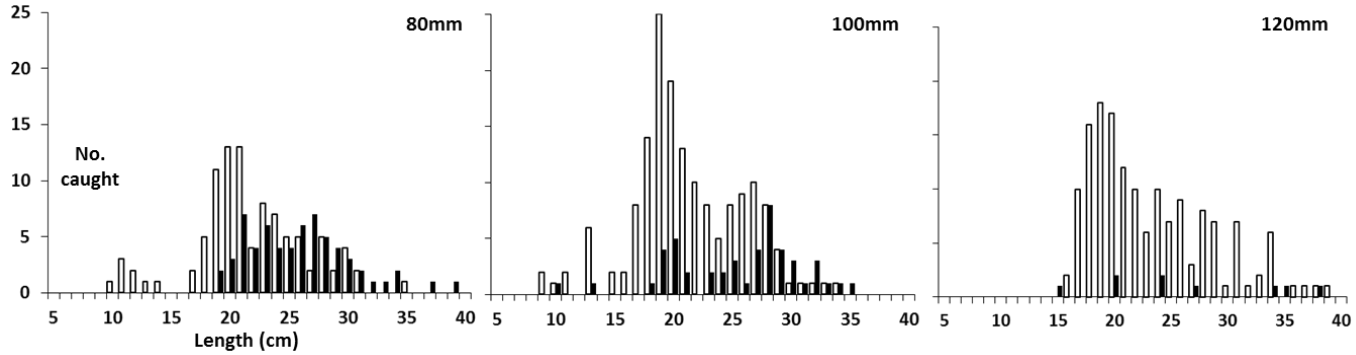

Figure 9. Witch: combined numbers caught at length by the control nets (white bars) in comparison to the test nets (black bars).

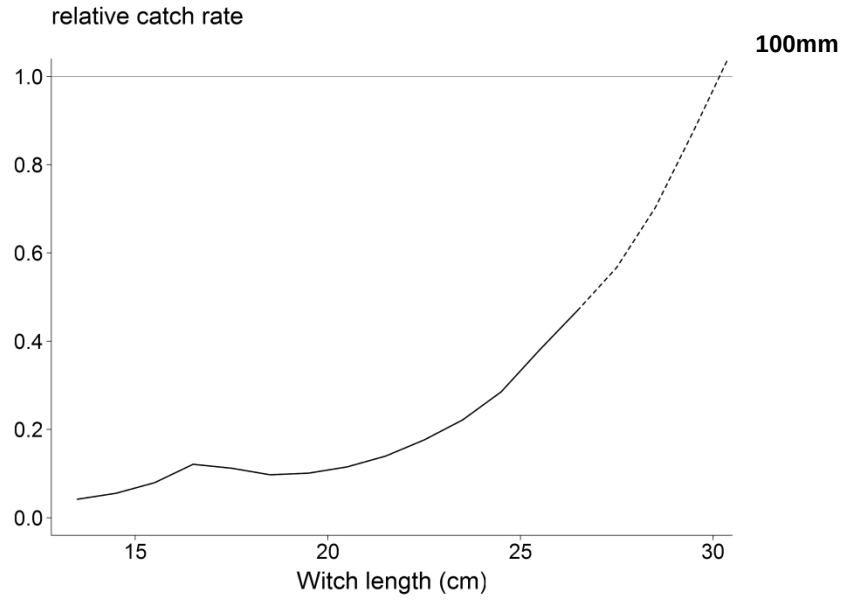

Figure 10. The relative catch rate of witch for 100 mm codend from smoothed data.

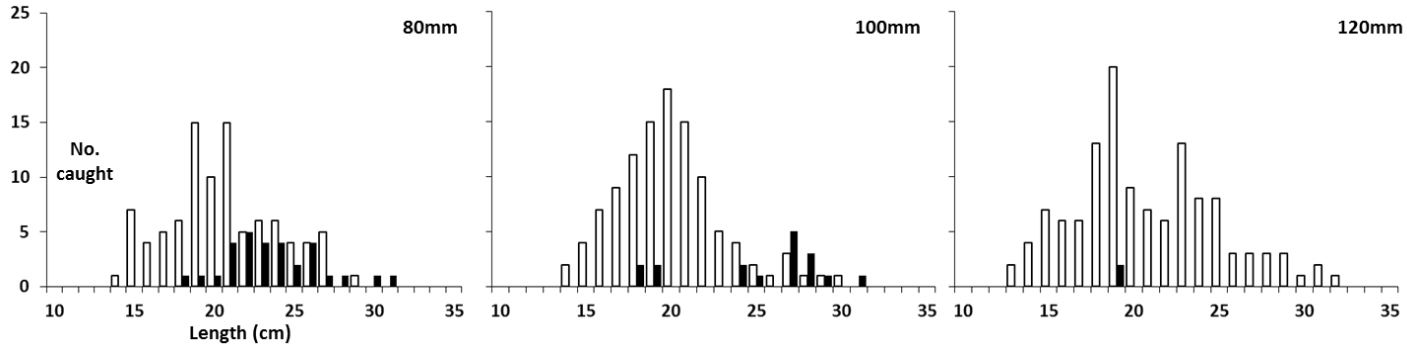

Figure 11. Lemon sole: combined numbers caught at length by the control nets (white bars) in comparison to the test nets (black bars).

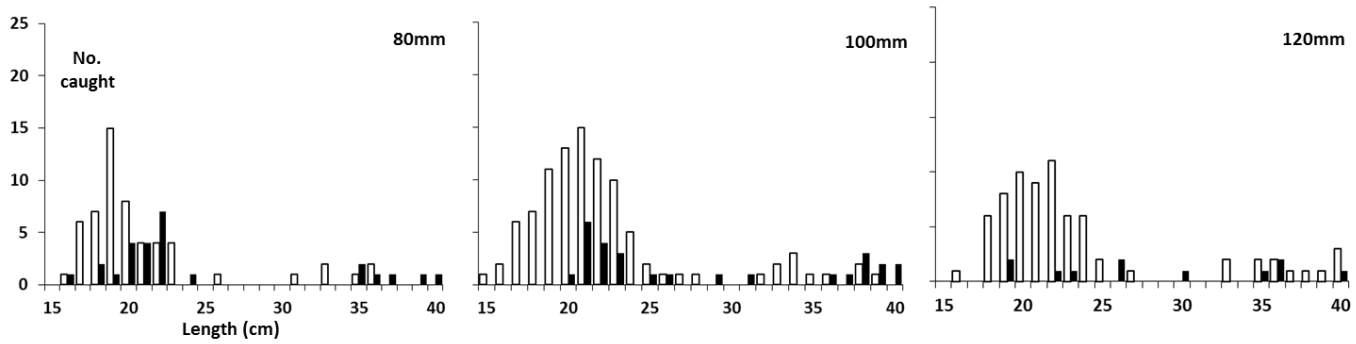

Figure 12. Hake: combined numbers caught at length by the control nets (white bars) in comparison to the test nets (black bars).

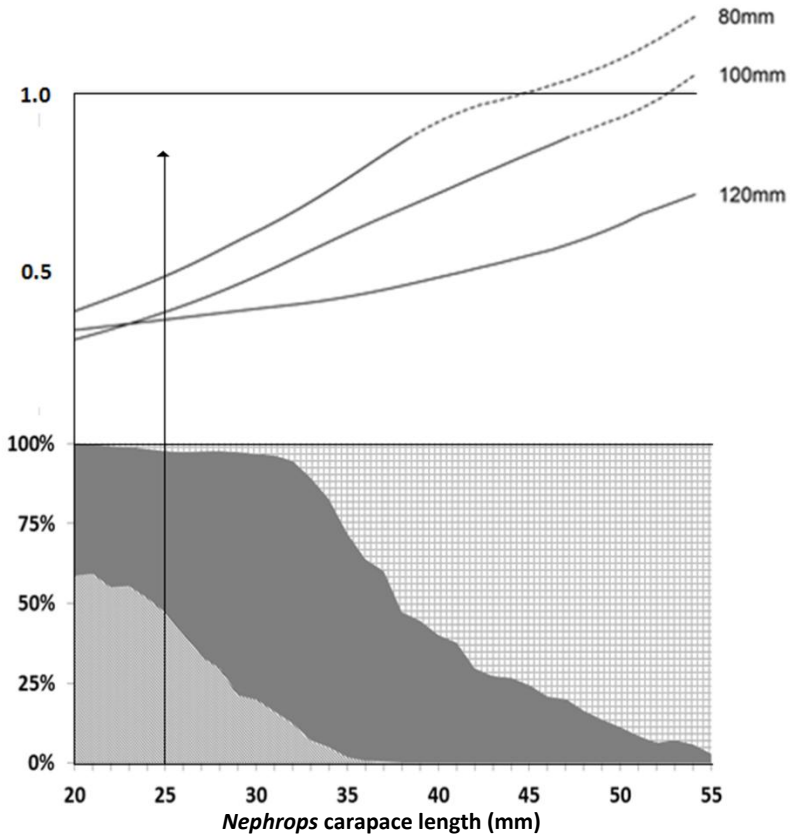

Figure 13. Bottom: approximate percentage 'fate at length' of commercially caught nephrops from the North and South Minch (source: MSS observer data 2013). Fates are illustrated as a percentage of three available to each mm carapace length grouping – light grey area: discarded, dark grey area: landed as tails, cross-hatched area: landed as whole. Top: relative catch rates of the 3 test gears as Figure 2 which can be applied to each length/fate. The length range illustrated is the same as that analysed during these trials.

Percentage fates as illustrated represent an amalgamation of observer data covering both the North and South Minch during all 4 quarters of 2013 and incorporate information from both 80 mm and 100 mm codends. The figure, then, should not be taken as definitive but as a guide. As in other areas market forces, seasonal forces, working logistics and individual vessel practice all heavily influence the patterns of tailing and landing of whole nephrops in the Scottish west coast fishery.

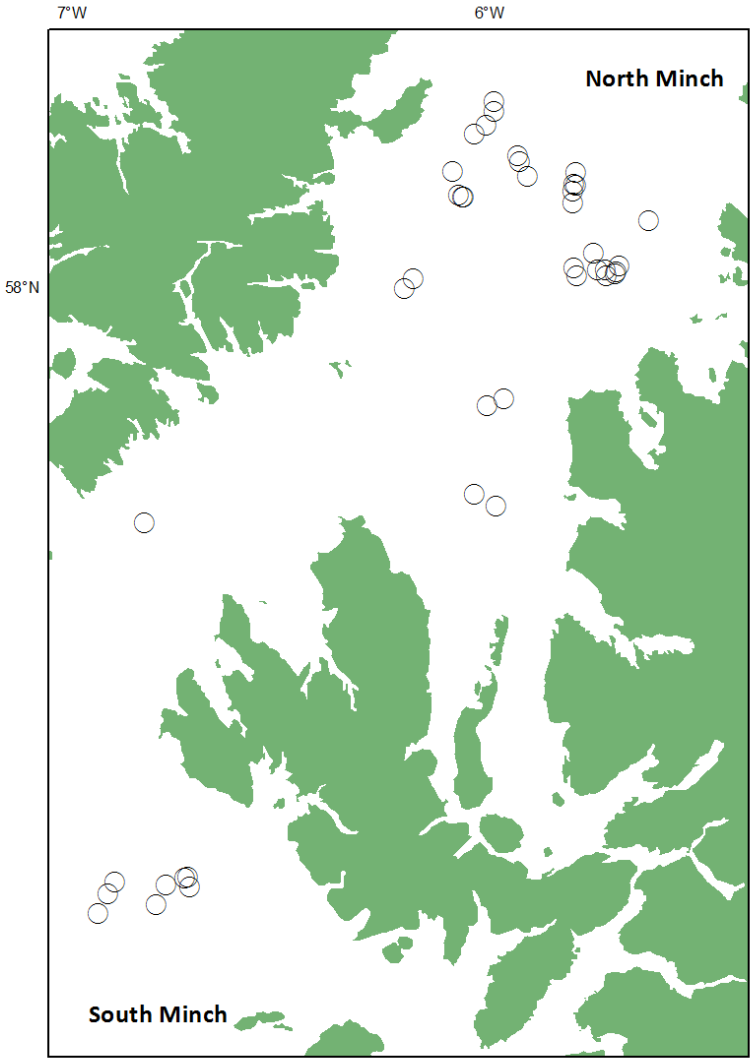

Figure 14. Approximate midpoints (open circles) of hauls undertaken during the trials.

Haul	Test	Control Net						Test Net						% bulk Wt.
no.	Config	Nephrops	Haddock	Whiting	others 1	others 2	Totals	Nephrops	Haddock	Whiting	others 1	others 2	Totals	reduction
1	80 Stbd	39.8	14.7	7.5	0.2	50	**112**	35.1	13.5	3.9	1.9	26	**80**	**28**
2	80 Stbd	127.2	62.8	11.0	4.7	124	**330**	92.7	21.6	5.4	10.4	93	**223**	**32**
3	80 Stbd	59.9	12.4	1.0	3.5	105	**182**	56.2	8.1	1.4	6.5	65	**137**	**25**
5	120 Stbd	136.5	53.6	8.6	3.7	44	**246**	61.3	2.7	0.5	4.7	13	**82**	**67**
6	120 Stbd	115.6	30.4	10.6	6.3	61	**224**	44.5	1.7	0.9	2.8	32	**82**	**63**
7	120 Stbd	126.1	24.8	6.4	6.0	72	**235**	39.6	1.9	0.2	0.8	34	**76**	**68**
8	100 Stbd	96.3	94.3	29.8	6.7	58	**285**	78.0	15.3	2.2	5.7	14	**115**	**60**
9	100 Stbd	151.1	83.4	33.0	10.2	107	**385**	122.8	8.1	2.4	5.4	25	**164**	**57**
10	100 Stbd	123.7	14.2	5.1	4.9	74	**222**	67.1	6.4	0.1	6.4	18	**98**	**56**
11	100 Stbd	55.6	14.4	4.5	8.1	205	**288**	26.4	10.2	2.5	5.9	126	**171**	**41**
12	100 Port	59.4	78.9	1.1	3.2	47	**190**	31.2	51.1	0.4	2.1	29	**114**	**40**
13	100 Port	26.4	80.1	0.7	2.1	66	**175**	11.8	33.9	0.7	3.0	25	**74**	**58**
14	100 Port	178.6	38.7	8.3	10.3	74	**310**	92.3	5.5	1.4	3.8	15	**118**	**62**
15	80 Port	89.2	35.6	7.2	3.7	98	**234**	63.1	6.4	5.8	4.2	15	**94**	**60**
16	80 Port	53.1	27.4	5.7	1.8	79	**167**	38.4	3.0	2.5	4.8	21	**70**	**58**
17	80 Port	54.0	44.3	6.8	2.7	103	**211**	33.5	13.6	2.3	4.1	17	**71**	**67**
18	80 Port	136.8	85.7	2.0	3.7	81	**309**	102.0	2.8	1.1	2.6	16	**124**	**60**
19	80 Port	203.0	30.2	5.9	9.4	79	**327**	133.5	1.8	1.3	8.8	31	**176**	**46**
20	80 Port	73.6	30.6	3.4	6.6	89	**203**	58.1	2.4	1.4	6.2	17	**85**	**58**
21	80 Port	100.0	28.3	5.0	7.4	52	**193**	75.2	1.4	0.2	1.1	33	**111**	**42**
23	100 Port	73.0	27.5	5.8	3.5	43	**153**	55.1	1.3	0.1	3.2	5	**65**	**58**
24	100 Port	136.0	33.0	4.9	3.3	72	**249**	70.0	1.8	0.3	1.5	8	**82**	**67**
25	100 Port	88.2	37.0	6.8	7.0	86	**225**	50.7	2.1	0.8	3.0	11	**68**	**70**
26	120 Port	44.0	9.7	0.3	5.2	101	**160**	21.4	9.7	0.0	2.5	24	**58**	**64**
27	120 Port	58.0	27.5	1.0	2.9	67	**156**	23.5	16.0	0.9	1.4	19	**61**	**61**
28	120 Port	58.3	11.9	4.9	2.8	74	**152**	25.9	7.4	0.2	1.6	22	**57**	**62**
29	120 Port	91.2	6.8	17.4	30.8	60	**206**	39.8	0.6	1.0	6.0	10	**57**	**72**
30	120 Port	60.3	1.6	5.3	9.1	38	**114**	28.3	0.0	0.9	11.3	11	**52**	**55**
31	120 Port	79.6	10.8	14.2	68.7	41	**214**	37.9	1.6	2.4	62.9	11	**116**	**46**
32	120 Port	88.6	9.4	10.7	16.3	40	**165**	42.3	4.1	3.4	34.9	25	**110**	**33**
33	100 Stbd	78.2	13.5	35.8	8.5	62	**198**	69.3	5.6	3.5	6.6	32	**117**	**41**
34	100 Stbd	63.9	9.3	12.8	14.5	91	**191**	48.9	5.0	3.2	8.0	44	**109**	**43**
35	100 Stbd	110.8	10.1	5.6	26.5	99	**252**	86.7	2.7	1.8	7.6	49	**148**	**41**
36	100 Stbd	85.6	6.7	10.0	45.6	149	**297**	64.8	3.0	0.7	13.6	30	**112**	**62**
37	120 Stbd	157.8	51.4	11.0	7.6	120	**348**	81.7	0.8	0.5	3.2	5	**91**	**74**
38	120 Stbd	67.4	50.5	50.4	10.4	112	**291**	36.1	1.8	0.5	2.0	52	**92**	**68**
39	120 Stbd	94.1	47.4	21.6	4.9	329	**497**	68.1	19.9	3.7	3.1	72	**167**	**66**
40	120 Stbd	154.8	40.4	23.2	4.6	343	**566**	73.8	16.1	7.3	3.9	52	**153**	**73**
41	80 Stbd	132.7	23.1	7.2	6.1	430	**599**	137.6	4.4	1.8	9.4	53	**206**	**66**
42	80 Stbd	85.9	52.5	24.7	4.7	340	**508**	73.9	1.8	2.5	3.3	27	**108**	**79**
43	80 Stbd	44.6	54.6	17.5	1.4	318	**436**	46.6	4.6	1.5	1.2	26	**80**	**82**

Table 1. Weight (kg) of *Nephrops*, haddock, whiting, other commercial species (others 1), non-commercial species and invertebrates (others 2) by haul number and test configuration (mesh size and whether fished port or starboard on the twin-rig). Missing haul numbers refer to foul hauls.

80mm				100mm				120mm			
Haul	Nephrops	Haddock	Whiting	Haul	Nephrops	Haddock	Whiting	Haul	Nephrops	Haddock	Whiting
1	88	92	52	8	81	16	7	5	45	5	6
2	73	34	49	9	81	10	7	6	38	5	8
3	94	65	146	10	54	45	3	7	31	8	4
15	71	18	80	11	47	71	55	26	49	100	0
16	72	11	44	12	53	65	37	27	41	58	89
17	62	31	34	13	45	42	89	28	44	62	4
18	75	3	54	14	52	14	16	29	44	9	6
19	66	6	22	23	75	5	1	30	47	1	16
20	79	8	41	24	51	5	6	31	48	15	17
21	75	5	5	25	57	6	12	32	48	44	32
41	104	19	26	33	89	42	10	37	52	2	5
42	86	3	10	34	77	54	25	38	54	3	1
43	104	8	8	35	78	27	31	39	72	42	17
				36	76	45	6	40	48	40	31
Overall	79	17	30	Overall	67	22	12	Overall	47	20	12

Table 2. Retention (% by weight) for the three main commercial species caught. It is important to note that these retention values will apply only to the length frequencies encountered (as illustrated in Figures 1, 3 and 5).

Haul no.	wing spreads Port	Stbd	Haul no.	wing spreads Port	Stbd
1	-	-	24	-	-
2	-	-	25	8.4	8.6
3	-	-	26	-	9.4
5	8.4	8.7	27	8.1	8.6
6	8.1	8.1	28	-	8.2
7	-	8.6	29	8.5	8.6
8	8.2	9.9	30	8.9	8.7
9	8.0	8.0	31	8.6	8.5
10	-	8.5	32	8.8	8.4
11	-	7.6	33	8.7	-
12	8.6	-	34	8.5	9.1
13	8.4	8.4	35	8.3	8.6
14	8.2	8.4	36	9.2	8.8
15	8.1	8.5	37	8.3	8.4
16	8.6	8.5	38	8.2	8.4
17	8.8	8.6	39	-	7.6
18	8.5	9.4	40	8.5	7.9
19	8.6	8.4	41	-	-
20	8.0	8.2	42	8.8	8.0
21	8.0	8.2	43	8.7	8.2
23	-	-			
mean overall wingspreads: Port - 8.4 Stbd - 8.5					

Table 3. Mean wingspreads (m) by haul. Missing values refer to periods of no data. Missing haul numbers refer to foul hauls.

Species	Window	Half-Range	Test Gear	80mm	100mm	120mm	control
Nephrops	21	19.5 - 54.5	80mm	-	0.022	0.000	0.000
			100mm	-	-	0.000	0.000
			120mm	-	-	-	0.000
Haddock	9	8.5 - 25.5	80mm	-	0.569	0.012	0.000
			100mm	-	-	0.022	0.000
			120mm	-	-	-	0.000
Whiting	13	9.5 - 32.5	80mm	-	0.024	0.000	0.000
			100mm	-	-	0.004	0.000
			120mm	-	-	-	0.000
Plaice	9	16.5 - 30.5	100mm	-	-	-	0.000
Witch	15	13.5 - 30.5	100mm	-	-	-	0.000

Table 4. P-values: pairwise comparisons between test gears and control. Shaded areas indicate significant difference (P<0.05).

Test mesh (nominal)	Approx. mesh size pre-Trial	% > nominal size	Codend twine number and thickness	Codend no. meshes deep	Codend approx. length	Straight section twine number and thickness	Overall Length	No. open meshes across
80	83	3.8 %	4mm single 80mm	-	-	4mm single 80mm	12m	51
100	104	4.0 %	5mm double 100mm	50	5m	5mm single 100mm	12m	44
120	124	3.3 %	5mm double 120mm	50	6m	5mm single 120mmm	12m	44

Table 5. Test codend makeup. All codends and straight sections were constructed from Brezline (PE).

mesh	pre-trials mean size	post-trials mean size
80mm	82.7	81.8
100mm	103.8	102.4
120mm	123.9	122.0

Table 6. Mean codend mesh measurements (30 measurements on each of top and bottom sheet over the area of selectivity during the trials). All measurements were taken with a standard Omega gauge on wet meshes.

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